



A model for attracting investment capital to enhance transport connectivity with Vietnam's Mekong Delta expressway network: an application of the Fuzzy Analytic Hierarchy Process

Hoang Van Long

Ho Chi Minh City University of Law, 02 Nguyen Tat Thanh Str., Xom Chieu Ward, Ho Chi Minh City, Vietnam

Abstract

By applying the Fuzzy Analytic Hierarchy Process (Fuzzy AHP), this study develops a model for attracting investment capital to enhance transport connectivity with the expressway network in Vietnam's Mekong Delta. The analysis identified five main factors affecting investment capital attraction: government and local policy support, efficiency and potential for regional economic development, the existing infrastructure system, business environment, and technology and innovation in the transportation industry. The results show that investment support policies are the most influential factor, followed by the region's economic development potential. The research proposes strategic recommendations to improve the policy framework and promote economic development, creating favorable conditions for attracting investment capital into the expressway network and contributing to the sustainable development of the Mekong Delta.

Keywords: transport infrastructure, support policy, development potential, business environment, innovation.

JEL classification: C44, F21, H54, O18, R40.

1. Problem statement

Previous studies have acknowledged that attracting investment capital into transportation projects, especially highway projects, constitutes a critical determinant of sustainable economic development at both national and regional levels (Hsu *et al.*, 2022; Nguyen *et al.*, 2022). Moreover, in the context of globalization and increasingly deepening international integration, the development of road traffic infrastructure not only contributes to improving connectivity (Ahmadzai *et al.*, 2019), enhancing labor productivity (Huang *et al.*, 2022), but also facilitates trade, investment, and economic cooperation across territories (Yontar, 2022). In Vietnam, the Mekong Delta is considered a strategic economic hub where attracting investment capital into transport infrastructure, especially the highway system, is of paramount importance. Such investment is essential for stimulating economic growth, improving people's quality of life, and narrowing regional development disparities. This perspective is further reinforced by Bach (2023), who similarly underscores the pivotal role of transportation infrastructure investment in regional development.

According to Vo (2024), the Mekong Delta of Vietnam possesses substantial economic potential across various sectors, including agriculture, aquaculture, tourism, and the processing industry. However, the development of this region remains constrained in part due to the incomplete highway system and its limited connectivity with other national economic regions. In recent years, the Vietnamese government has introduced numerous policies aimed at supporting and attracting investment in highway infrastructure in the Mekong Delta; however, the outcomes have not met expectations. Highway projects aimed at linking the Mekong Delta with major economic regions, such as Ho Chi Minh City, the Southeast region, and international border gates, continue to face significant challenges related to technology and investment capital.

In this context, research on models for attracting investment capital into transport projects connecting to the highway system in the Mekong Delta has become increasingly crucial. This study aims to analyze and propose effective models for investment mobilization, taking into account the region's specific characteristics and current socio-economic development trends. Developing a comprehensive highway network that links the Mekong Delta with other regions is not only a solution to overcome the existing infrastructure limitations, but also opens up new development opportunities, creating strong incentives to attract both domestic and foreign investment.

2. Research methodology

2.1. Literature review

A substantial body of research has identified key factors that affect investment attraction in transport infrastructure projects, particularly those related to the road and highway systems.

Cui *et al.* (2022) and Esmailpour *et al.* (2020) believe that investment policies enacted by governments and local authorities play a crucial role in creating favorable conditions for investors. These policies should include measures such as tax exemptions and reductions (Martilla and James, 1977), financial support (Cvelbar and Dwyer, 2013), and the streamlining of administrative procedures to attract potential investors (Krasheninina *et al.*, 2022). Furthermore, Hu *et al.* (2018) suggested that local support policies should be developed in an investor-friendly, transparent, and effective manner to maximize their impact.

The efficiency and potential of regional economic development are critical factors in determining the capacity to attract investment capital (Garza-Reyes *et al.*, 2016; Özceylan *et al.*, 2016; Zawawi *et al.*, 2017). Developing countries like Vietnam, where agriculture, fisheries and tourism are recognized as key economic sectors, possess great potential to mobilize investment resources. However, regional economic development still needs to be further promoted through policies to support businesses (Krupowicz *et al.*, 2017), improve the investment environment (Singh *et al.*, 2018) and develop highly qualified human resources (Fusco *et al.*, 2016).

Available infrastructure and transport connectivity are other important factors influencing investment attraction and should therefore be prioritized by policymakers. Strano *et al.* (2017) explained that although transport infrastructure in developing countries has improved remarkably in recent years, considerable limitations remain in terms of connectivity with other key economic regions. Therefore, upgrading and developing transport infrastructure, especially the highway system, is necessary to enhance investment appeal, a view also supported by Wang and Huang (2016).

The quality of the business and investment environment is widely acknowledged as an indispensable determinant of investment attraction. Asakura and Kashiwadani (1991) argued that a friendly, stable, transparent and highly competitive business environment is highly attractive to both domestic and foreign investors. Similarly, Rivera-Royero *et al.* (2022) emphasized the importance of comprehensive reforms in legal frameworks and investment policies for ensuring effective management and supervision mechanisms.

In addition to the four main factors mentioned above, technological advancement and innovation in the transportation industry are increasingly recognized as vital drivers of investment attraction. The adoption of intelligent traffic management systems (Xu *et al.*, 2016), modern building materials (Zhang and Wang, 2016), and green transportation means (Krupowicz *et al.*, 2017) not only improves operational efficiency but also reduces costs and enhances project sustainability. Such innovations significantly enhance the appeal of infrastructure projects, particularly for green investment funds and international organizations dedicated to sustainable development.

2.2. Model of Fuzzy AHP analysis

There are some basic steps in the Fuzzy AHP, including:

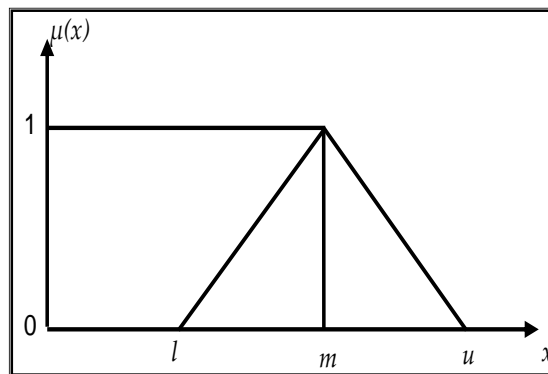
a) *Definition of fuzzy pairwise comparison matrix*

Assuming $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$ are fuzzy numbers with features:

$$\tilde{a}_{ij} = \begin{cases} [l_{ij}, m_{ij}, u_{ij}], & \text{if } i > j \\ [1, 1, 1], & \text{if } i = j \\ [\frac{1}{u_{ji}}, \frac{1}{m_{ji}}, \frac{1}{l_{ji}}], & \text{if } i < j \end{cases} \quad (1)$$

In graph, $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$ can be performed as picture 1.

FIGUREE 1: Fuzzy number graph



Fuzzy comparison pairwise matrix can be indicated as:

$$\tilde{A} = [\tilde{a}_{ij}]_{n \times n} = \begin{bmatrix} 1 & \tilde{a}_{12} & \dots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \dots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \dots & 1 \end{bmatrix} \quad (2)$$

b) Aggregating expert's decisions

Assuming we have an m-by-m fuzzy comparison pairwise matrix from m experts. The matrix is aggregated according to formula (Hsu *et al.*, 2023; Hsu *et al.*, 2022):

$$\tilde{a}_{ij} = [l_{ij}, m_{ij}, u_{ij}] = \left[\min_{1 \leq k \leq m} \{a_{ij}^{(k)}\}, \left(\prod_{k=1}^m a_{ij}^{(k)} \right)^{1/m}, \max_{1 \leq k \leq m} \{a_{ij}^{(k)}\} \right] \quad (3)$$

c) Check the consistency of fuzzy pairwise comparison matrices

Checking the consistency of the matrix constructed in step 2 can be processed with the following formula (Wang and Lin, 2017):

$$GCI(\tilde{A}) = \max \left\{ \frac{2}{(n-1)(n-2)} \sum_{i < j} \left(\log a_{ij}^M - \frac{1}{n} \sum_{k=1}^n \log a_{ik}^M + \log a_{kj}^M \right)^2; \right. \\ \left. \frac{1}{2(n-1)(n-2)} \sum_{i < j} \left[\log a_{ij}^L + \log a_{ij}^U - \frac{1}{n} \sum_{k=1}^n \left(\log a_{ik}^L + \log a_{ik}^U + \log a_{kj}^L + \log a_{kj}^U \right) \right]^2 \right\} \quad (4)$$

The comparison value to determine the consistency of the matrix will be based on the number of criteria of the matrix. Specifically:

$$GCI = \begin{cases} 0,3147 & \text{if } n = 3 \\ 0,3562 & \text{if } n = 4 \\ 0,3700 & \text{if } n > 5 \end{cases} \quad (5)$$

d) De-fuzzifying

The de-fuzzifying matrix is calculated with the formula (Hsu *et al.*, 2023; Hsu *et al.*, 2022):

$$a_{ij} = (l_{ij} \cdot m_{ij}^2 \cdot u_{ij})^{\frac{1}{4}}, \quad (6)$$

$i = 1, 2, \dots, n, \quad j = 1, 2, \dots, n$

e) Estimating the fuzzy weights of criteria and sub-criteria

According to matrix theory, the weights of factors and evaluation criteria will be estimated based on the eigenvalues of the pairwise comparison simple matrix $A = [a_{ij}]_{n \times n}$.

$W = [w_1, w_2, \dots, w_n]$ is the weight vector to be found, which can be determined based on the formula below (Saaty, 2008):

$$\begin{cases} AW = /W \\ \sum_{i=1}^n w_i = 1, \quad i = 1, 2, \dots, n. \end{cases} \quad (7)$$

2.3. Factor structure model and criteria for attracting investment

This study employs Fuzzy AHP to evaluate and select a model to attract investment into the highway system in the Mekong Delta of Vietnam. Accordingly, we propose a factor structure model and criteria influencing investment attraction. Drawing on the literature reviewed above, investment attraction in highway infrastructure is determined by five main factors with 20 criteria, as shown in Table 1.

TABLE 1: Model of factor structure and criteria for attracting investment

Factor	Criteria	
Support policies from the government and localities (CS)	Incentives of tax policies	CS1
	Investment capital from government	CS2
	Favorable legal regulations	CS3
	Local supporting	CS4
Efficiency and potential for regional economic development (TN)	GDP growth	TN1
	Industry development potential	TN2
	Average income per capita	TN3
	Foreign investment attraction	TN4
Available infrastructure system (HT)	Availability of road system	HT1
	Port and railway system	HT2
	Connectivity to other economic regions	HT3
	Quality of existing infrastructure	HT4
Business environment (MT)	Business transparency	MT1
	Political stability	MT2
	Low investment risk	MT3
	Market competitiveness	MT4
Technology and innovation in the transportation industry (CN)	Digital transformation in traffic management and operation	CN1
	Development of environmentally friendly means of transport	CN2
	Application of advanced construction materials	CN3
	Intelligent traffic management system	CN4

Source: Literature review.

2.4. Research sample

This study surveyed 21 experts with experience in major transport infrastructure projects in Vietnam from 2020 to 2024 to evaluate and select an appropriate model for attracting investment into the highway transport system.

After defining the research sample, the team designed a survey to collect opinions from experts relating to the criteria for attracting investment into the highway system. Data collection took place from May to August 2024, and the information survey forms are presented as follows:

TABLE 2: Descriptive analysis

Type	Description	Frequency	Ratio (%)
Categories of investors	State-owned enterprises	17	80,95
	Private enterprises	2	9,52
	Foreign enterprises	2	9,52
Area	Domestic	19	90,48
	International	2	9,52
Investment experience	Under 5 years	6	28,57
	From 5 to 10 years	11	52,38
	Above 10 years	4	19,05
Education	Undergraduate	16	76,19
	Graduate	5	23,81
Position	Head of holding company/ corporation	4	19,05
	Head of unit or company member	9	42,86
	Head of department	6	28,57
	Others	2	9,52

Source: Survey data in 2024.

2.5. Checking the consistency

This study applies the Fuzzy AHP to evaluate five factors - CS, TN, HT, MT, CN (as outlined in Table 1). Each expert's survey is indicated as a single matrix. Applying the formula as presented above, these 21 matrices are changed into a fuzzy matrix. The aggregated fuzzy matrices for the identified factors are presented as follows:

$$\tilde{A} = \begin{pmatrix} 1.00 & 1.00 & 1.00 & 1.11 & 2.17 & 5.00 & 1.86 & 2.39 & 5.00 & 0.92 & 2.31 & 7.00 & 0.53 & 2.61 & 8.00 \\ 0.20 & 0.46 & 0.90 & 1.00 & 1.00 & 1.00 & 0.68 & 2.90 & 4.00 & 0.87 & 1.27 & 3.00 & 0.51 & 1.73 & 6.00 \\ 0.20 & 0.42 & 0.54 & 0.25 & 0.34 & 1.48 & 1.00 & 1.00 & 1.00 & 0.47 & 2.81 & 5.00 & 0.76 & 1.95 & 5.00 \\ 0.14 & 0.43 & 1.09 & 0.33 & 0.79 & 1.15 & 0.20 & 0.36 & 2.15 & 1.00 & 1.00 & 1.00 & 0.275 & 1.23 & 7.00 \\ 0.13 & 0.38 & 1.89 & 0.17 & 0.58 & 1.96 & 0.20 & 0.51 & 1.32 & 0.14 & 0.81 & 3.64 & 1.00 & 1.00 & 1.00 \end{pmatrix}$$

Applying formula 4, the GCI coefficient of this matrix is estimated to be 0.3511, so this matrix is considered to be consistent. In the next step, the above integrated matrix is processed using formula 6, yielding the following results:

$$A = \begin{vmatrix} 1.00 & 2.26 & 2.70 & 2.42 & 2.32 \\ 0.44 & 1.00 & 2.18 & 1.43 & 1.74 \\ 0.37 & 0.46 & 1.00 & 2.07 & 1.95 \\ 0.41 & 0.70 & 0.48 & 1.00 & 1.31 \\ 0.43 & 0.57 & 0.51 & 0.77 & 1.00 \end{vmatrix}$$

3. Discussion

Applying formula 7, the coefficients of matrix A are estimated as follows: (CS, TN, HT, MT, CN) = (0.3668; 0.2198; 0.1726; 0.1281; 0.1127). Similarly, the weights of the factors and criteria in the research sample are estimated in Table 3.

The empirical results in Table 3 indicate that support policies from the government and localities (CS) exert the most substantial impact on investment decisions in highway projects in the Mekong Delta, with a coefficient of 36.68% - more than one-third of investors' decisions are influenced by support policies from the government and localities. Such a high rate confirms the leading role of policy in either facilitating or hindering investment in highway projects.

This finding is consistent with Vieira *et al.* (2019), who examined investment attraction in the Brazilian road transport system. Previous studies have acknowledged that cooperation and support from local authorities, such as land acquisition and expansion (Yontar, 2022), provision of basic infrastructure (Bach, 2023), or streamlining of licensing procedures (Cui *et al.*, 2022), can reduce project costs and implementation time. Such cooperation and support are especially crucial in the development of high-speed transport systems, where factors such as site clearance and obtaining construction permits can be complex and expensive. When compared with other factors - such as the efficiency and potential of regional economic development, the availability of transport infrastructure, and the quality of business environment - the analysis shows that while other factors remain significant, none can replace the role of investment support policies. The critical importance of these policies may imply that, in the current context, investors perceive government and local policies as a form of "insurance" against other potential risks.

TABLE 3: Weights of factors and criteria

Factor	Weight (%)		Local weight (%)	Global weight (%)	Ranking
CS	36.68	CS1	17.41	6.39	7
		CS2	17.62	6.46	6
		CS3	41.00	15.04	1
		CS4	23.97	8.79	2
TN	21.98	TN1	33.28	7.31	3
		TN2	24.51	5.39	9
		TN3	11.47	2.52	15
		TN4	30.74	6.76	5
HT	17.26	HT1	33.74	5.83	8
		HT2	14.18	2.45	16
		HT3	40.72	7.03	4
		HT4	11.36	1.96	18
MT	12.81	MT1	12.09	1.55	19
		MT2	40.62	5.20	10
		MT3	25.66	3.29	13
		MT4	21.63	2.77	14
CN	11.27	CN1	12.95	1.46	20
		CN2	33.42	3.77	11
		CN3	20.93	2.36	17
		CN4	32.71	3.69	12

Source: Data survey in 2024.

The efficiency and potential for regional economic development (TN) are also significant factors influencing investment attraction in the Mekong Delta's highway system, with a coefficient of 21.98%. Despite not being as strong as investment support policies, the economic development potential of the region remains highly influential in shaping investment decisions. Vo (2024) believed that the highway system not only facilitates connectivity between the Mekong Delta and other economic regions but also creates spillover effects, such as increased trade, reduced transportation costs, and improved overall economic efficiency of the region. Therefore, investors recognize that improvements in transportation infrastructure can spark a positive ripple effect in the local economy, thereby strengthening their confidence in investing.

Among the twenty criteria assessed, several stand out as particularly influential in shaping investment choices. The highest-ranked criterion is favorable legal regulations (15.04%), highlighting the importance of a clear and stable legal environment in ensuring the safety and transparency of investments. Local support is also highly appreciated (8.79%), as cooperation and commitment from local authorities can help reduce risks and increase project implementation efficiency. GDP growth (7.31%) further reflects investors' interest in the region's profitability and economic potential. Connectivity to other economic regions emphasizes the role of transportation in expanding markets and facilitating inter-regional trade (7.03%). Finally, foreign investment attraction shows that the interest of international investors can be a positive indicator (6.76%) of regional development potential, which in turn strengthens the confidence of domestic investors.

4. Conclusion

This research highlights the importance of developing a model to attract investment capital for transport connectivity and the highway system in the Mekong Delta. In general, the development of transport infrastructure, especially the highway system, is a key factor for the sustainable economic development of this region. The Mekong Delta, with significant economic potential in the fields of agriculture, aquaculture, and tourism, presents considerable opportunities for transformation through improvements and expansions to its transport network. However, attracting investment capital for transport projects remains a complex challenge that demands a comprehensive strategy, combining policies, economic potential, and strong commitment from local authorities.

The findings of this research provide some strategic recommendations for promoting investment attraction in the Mekong Delta's highway transport system. Firstly, building close coordination among government bodies to establish stable and attractive policy frameworks is crucial, thereby ensuring transparency and consistency in implementation. Secondly, it is essential to continue promoting the economic development of the region, enhancing competitiveness, and fully leveraging the available economic potential. Finally, transport infrastructure construction should be carried out in a synchronized manner to ensure effective connectivity with other economic regions, thereby creating favorable conditions for trade and investment.

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Article history

Received on September 6, 2024

Revised on September 21, 2024

Accepted on September 23, 2024